



U.S. NUCLEAR REGULATORY COMMISSION

STANDARD REVIEW PLAN

OFFICE OF NUCLEAR REACTOR REGULATION

2.4.7 ICE EFFECTS

REVIEW RESPONSIBILITIES

Primary - ~~Hydrologic & Geotechnical Engineering Branch (HGEB)~~
Mechanical and Civil Engineering Branch (EMEB)

Secondary - None

I. AREAS OF REVIEW

The hydrometeorologic design basis is developed in this section of the ~~safety analysis report (SAR)~~ **site safety assessment for an early site permit application** to ~~assure~~ **ensure** that safety-related facilities and water supply are not affected by ice flooding or blockage. The areas of review include:

1. The regional history and types of historical ice accumulations (i.e., ice jams, wind-driven ice ridges, floes, etc.).
2. The potential for ice-produced forces on, or blockage of, safety-related facilities.
3. The potential effects of ice-induced high or low flow levels on safety-related facilities and water supplies.

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If there is evidence of potential structural effects, the Structural Engineering Branch (SEB) will be requested by HGEB to EMEB will ascertain whether these effects are properly considered in the site safety assessment in the structural design basis for the plant; similarly, if there is evidence of potential mechanical effects, the Mechanical Engineering Branch (MEB) and the Auxiliary Systems Branch (ASB) will be requested by HGEB to ascertain whether these effects are properly considered in the mechanical design basis for the plant. The staff will develop a position based on the analysis; resolve, if possible, differences between the applicant's and staff's estimates of ice effects; and write the safety evaluation report (SER) input accordingly.

II. ACCEPTANCE CRITERIA

Acceptance criteria for this SRP section are based on meeting the requirements of the following regulations:

1. ~~10 CFR Part 50, 50.55a as it requires structures, systems, and components to be designed and constructed to quality standards commensurate with the importance of the safety function to be performed.~~
2. ~~General Design Criterion 2 (GDC 2) as it requires structures, systems, and components important to safety to be designed to withstand the effects of natural phenomena.~~
3. 10 CFR Parts 52 and 100 as ~~it relates~~ they relate to identifying and evaluating hydrologic features of the site.

Compliance with 10 CFR 52.17(a) and 10 CFR 100.20(c) requires that the site's physical characteristics (including seismology, meteorology, geology, and hydrology) be taken into account when determining its acceptability for a nuclear power reactor. To satisfy the hydrologic requirements of 10 CFR Parts 52 and 100,

USNRC STANDARD REVIEW PLAN

Standard review plans are prepared for the guidance of the Office of Nuclear Reactor Regulation staff responsible for the review of applications to construct and operate nuclear power plants. These documents are made available to the public as part of the Commission's policy to inform the nuclear industry and the general public of regulatory procedures and policies.

Standard review plans are not substitutes for regulatory guides or the Commission's regulations and compliance with them is not required. The standard review plan sections are keyed to the Standard Format and Content of Safety Analysis Reports for Nuclear Power Plants. Not all sections of the Standard Format have a corresponding review plan.

Published standard review plans will be revised periodically, as appropriate, to accommodate comments and to reflect new information and experience.

Comments and suggestions for improvement will be considered and should be sent to the U.S. Nuclear Regulatory Commission, Office of Nuclear Reactor Regulation, Washington, D.C. 20555.

the applicant's safety assessment must contain a description of any icing phenomena with the potential to result in adverse effects to the intake structure or other safety-related facilities for a nuclear power plant or plants of specified type that might be constructed on the proposed site. Ice-related characteristics historically associated with the site and region must be described, and an analysis must be performed to determine the potential for flooding, low water, or ice damage to safety-related structures, systems, or components. The analysis must be sufficient to evaluate the site's acceptability and to assess the potential for those characteristics to influence the design of structures, systems, or components important to safety for a nuclear power plant or plants of specified type that might be constructed on the proposed site. Meeting this requirement provides assurance that structures, systems or components important to safety for a nuclear power plant or plants of specified type could be designed to withstand the effects of potentially severe icing conditions.

Note: Though not required at the early site permit stage, the applicant for a combined license (COL) will need to demonstrate compliance with General Design Criterion 2 as it relates to structures, systems, and components important to safety being designed to withstand the effects of natural phenomena.

Appropriate sections of the following documents are used by the staff to ~~assure~~ ensure that the Commission regulations identified above are met: Regulatory Guide 1.59 provides guidance for developing the hydrometeorologic design basis; ~~Regulatory Guide 1.29 identifies the safety-related structures, systems, and components;~~ and Regulatory Guide 1.102 describes acceptable flood protection to prevent the safety-related facilities from being adversely affected.; ~~and Regulatory Guide 1.27 describes the ultimate heat sink capabilities which apply.~~

To meet the requirements of ~~10 CFR Part 50, §50.55a, GDC 2, and 10 CFR Parts~~ 52 and 100 as they relate to ice effects the following specific criteria are used:

- A. Publications of the National Oceanic and Atmospheric Administration (NOAA), the United States Geologic Survey (USGS), the Corps of Engineers, and other sources are used to identify the history and potential for ice formation in the region. Historical maximum

depths of icing should be noted, as well as mass and velocity of any large floating ice bodies. The phrase "historical low water ice affected" or similar phrases in stream flow records (USGS and State publications) will alert the reviewer to the potential for ice effects. The following items must be considered and evaluated, if found necessary, ~~in the design of protection of safety-related facilities and water supplies.~~

- (1) The regional ice and ice jam formation history must be described to enable an independent determination of the need for including ice effects in the design basis.
- (2) If icing has not been severe, based on regional icing history, design considerations must be presented (e.g., return of a portion of low-grade heat to the intake) to ~~assure~~ **ensure** that icing or ice blockage of intake screens and pumps ~~will~~ **would** not adversely affect safety-related facilities and water supplies. **(This item is to be addressed at the COL stage.)**
- (3) If the potential for icing is severe, based on regional icing history, it must be shown that water supplies capable of meeting safety-related requirements are available from under the ice formations postulated and that safety-related equipment ~~is~~ **could be** protected from icing as in item (2), above. If ~~not~~ **this cannot be shown**, it must be demonstrated that alternate sources of water are available, that they ~~could be~~ **are** protected from freezing, and that the alternate source ~~is~~ **would be** capable of meeting safety-related requirements in such situations. ~~Ice loading must have been included in the structural design basis, if severe icing is possible.~~
- (4) If floating ice is prevalent, based on regional icing history, ~~consideration of~~ **potential** impact forces on ~~the~~ safety-related intakes must be **considered** ~~a consideration in the design basis.~~ The dynamic loading caused by floating ice must be

included in the structural design basis. (This item is to be addressed at the COL stage.)

- (5) If ice blockage of the river or estuary is possible, it must be demonstrated that the resulting water level in the vicinity of the site has been considered ~~in establishing the flood and water supply design bases~~. If this water level would adversely affect the intake structure, or other safety-related facilities of a nuclear power plant or plants of specified type that might be constructed on the proposed site, it must be demonstrated that an alternate safety-related water supply ~~will~~ **would** not also be adversely affected.

- B. The applicant's estimates of potential ice flooding or low flows are acceptable if the estimates are no more than 5% less conservative than the staff's estimates. If the applicant's estimates are more than 5% less conservative than the staff's,¹ the applicant should fully document and justify its estimates or accept the staff's estimates ~~and redesign applicable flood protection~~. The suggested criteria of Regulatory Guide 1.27 apply when the water supply comprises part of the ultimate heat sink.

III. REVIEW PROCEDURES

Applicable literature describing historical occurrences of icing in the region is reviewed to determine if icing protection should be considered in the design of safety-related facilities. If considered necessary, the most likely types of icing conditions (floating ice, river blockage by ice buildup, frazil, etc.) are listed, and the potential impact ~~on plant design~~ of each type **on the design of a nuclear power plant or plants of specified type that might be constructed on the proposed site** is identified. Criteria of the Corps of Engineers and others provide a means of assessing icing impact and methods of mitigating adverse effects.

¹Based on the difference between normal water levels and the flood event or low water.

For each type of icing condition, preliminary independent estimates of the "worst case" will be made by either conservative statistical or deterministic techniques.

If the applicant's estimates of ice effects are comparable to the staff's preliminary analysis, the staff will concur with the applicant's estimates. If the preliminary analysis indicates the applicant's estimates of ice effects are not comparable to the staff's estimates, the staff's analysis will be repeated using more realistic techniques.

The above reviews are performed only when applicable to the site or site regions. Some items of review may be done on a generic basis.

IV. EVALUATION FINDINGS

For ~~construction permit (CP)~~ **early site permit** reviews, the findings will summarize the applicant's and staff's estimates of the potential for ice flooding, ice blockage of water intakes, ice forces on structures, and the minimum low water levels (from upstream ice blockage). If the applicant's estimates are within acceptable margins (described in Acceptance Criteria), staff concurrence with the applicant's estimate will be stated. If the applicant's estimates are not within acceptable margins ~~or~~, if the staff predicts potential blockage of the intake. ~~or if the proposed plant~~ **a nuclear power plant or plants of specified type that might be constructed on the proposed site** may be adversely affected, a statement of the staff bases will be made. If the icing conditions do not constitute a design basis, the findings will so indicate.

~~For operating license (OL) reviews of plants for which detailed icing reviews were made at the CP stage, the CP conclusions will be referenced. However, a review will be made to assure that the design basis established in the CP review has been implemented properly. In addition, a review of icing records since the CP review will be made. If no CP review was undertaken (of the scope indicated), this fact will be noted in the OL findings.~~

A sample CP **early site permit** statement follows:

~~The staff concludes that with respect to ice flooding the plant design is acceptable and meets the requirements of~~

~~General Design Criterion 2 and 10 CFR Part 100. This conclusion is based upon the following analysis which shows that safety-related structures identified in Regulatory Guide 1.29, are designed to withstand the effects of ice floods in accordance with position 1 of Regulatory Guide 1.59. This position is met in accordance with position 1.a of Regulatory Guide 1.102 which discusses dry sites.~~

As set forth above, ice flooding, which is common on the A River at the makeup intake structure, could only affect the river intake structure of a nuclear power plant of type specified by the applicant; this which would not result in any adverse effects to the plant's safety-related facilities. The applicant states that ice flooding may possibly raise the water surface near the A River intake to a maximum elevation of about 555 feet 170 m (555 ft) MSL. The applicant further states that Also, ice and ice flooding on the A River tributaries outside the cooling lake will not affect the plant facilities of a nuclear plant of type specified by the applicant that might be built at the site. The major tributary nearest the plant site is the B Creek with the closest point located about one mile 1.6 km (1 mi) to the southeast of the site. The applicant concludes that, because Because of the distance from the proposed site and the wide floodplain of the river, there will be no adverse effects at the plant site due to ice in the river and consequent flooding. We concur with this conclusion.

Therefore, the staff concludes that, with respect to ice flooding, the applicant has adequately described the potential adverse impacts of icing on the safety-related facilities of a nuclear power plant of type specified by the applicant that might be constructed on the proposed site. In addition, the applicant has adequately described the ice-related characteristics historically associated with the site and region. The safety assessment demonstrates that the site is acceptable and meets the requirements of 10 CFR Part 52 and 10 CFR Part 100.

~~The staff concludes that with respect to ice blockage of water intakes the plant design is acceptable and meets the requirements of 10 CFR Part 50, 50.55a General Design Criterion 2. This conclusion is based upon the following analysis, which shows that position 2 of Regulatory Guide~~

~~1.27 is met with respect to ice blockage of essential water intakes.~~

~~— The safety-related pumps from the cooling lake are to be protected from ice blockage by means of traveling screens, stop logs, and trash racks located at the front of the lake screenhouse. In addition, the applicant proposes a warmup line from the circulating water discharge which will keep the inlet water temperature 40°F during winter operation. An essential cooling water screen bypass pipe is also available.~~

~~— We concur with the applicant that icing or ice flooding should not adversely affect the plant's safety-related facilities.~~

V. IMPLEMENTATION

The following is intended to provide guidance to applicants and licensees regarding the NRC staff's plans for using this SRP section.

This SRP section will be used by the staff when performing safety evaluations of early site permit applications submitted by applicants pursuant to 10 CFR Part 52. Except in those cases in which the applicant proposes an acceptable alternative method for complying with specified portions of the Commission's regulations, the method described herein will be used by the staff in its evaluation of conformance with Commission regulations.

Implementation schedules for conformance to parts of the method discussed herein are contained in the referenced regulatory guides.

VI. REFERENCES

- ~~1. 10 CFR Part 50, 50.55a, "Codes and Standards."~~
2. 10 CFR Part 50, Appendix A, General Design Criterion 2, "Design Bases for Protection Against Natural Phenomena."
3. 10 CFR Part 100, "Reactor Site Criteria."

4. E. Brown and G. C. Clark, "Ice Thrust in Connection with Hydro-Electric Design," Engineering Journal, pp. 18-25, 1932.
5. V. T. Chow (ed.), "Handbook of Applied Hydrology," McGraw-Hill Book Company, New York (1964).
6. O. Devik, "Freezing Water and Supercooling," Jour. of Glaciology, Vol. 1, No. 6, pp. 307-309 (1949).
7. N. E. Dorsey, "Properties of Ordinary Water Substances," Reinhold Publishing Company, New York (1940).
8. H. T. Mautis (ed.), "Review of Properties of Snow and Ice," Report 4, Corps of Engineers, Snow, Ice and Permafrost Research Establishment (1951).
9. E. Rose, "Thrust Exerted by Expanding Ice Sheet," Trans. Am. Soc. Civil Engineers, Vol. 112, pp. 871-900 (1947).
10. J. T. Wilson, "Coupling Between Moving Loads and Flexural Waves in Floating Ice Sheets," Report No. 34, Corps of Engineers, Snow, Ice, and Permafrost Research Establishment (1955).
11. J. T. Wilson, J. H. Zumberge, and E. W. Marshall, "A Study of Ice on an Inland Lake," Report No. 5, Corps of Engineers, Snow, Ice, and Permafrost Research Establishment (1954).
12. "River Ice Jams - A Literature Review," Engineer Technical Letter No. 1110-2-58, Corps of Engineers (1969).
13. "Design of Small Dams," Bureau of Reclamation, U.S. Department of the Interior (1973).
14. J. H. Zumberge and J. T. Wilson, "Quantitative Studies of Thermal Expansion and Contraction of Lake Ice," Jour. of Geophysical Research, Vol. 61, pp. 374-383 (1953).
15. "Surface Water Supply of the United States," U.S. Geological Survey. surface water supply papers as applicable to the plant site region.

16. Regulatory Guide 1.27, "Ultimate Heat Sink for Nuclear Power Plants."
17. Regulatory Guide 1.29, "Seismic Design Classification."
18. Regulatory Guide 1.59, "Flood Design Basis for Nuclear Power Plants."
19. Regulatory Guide 1.70, "Standard Format and Content of Safety Analysis Reports for Nuclear Power Plants."
20. Regulatory Guide 1.102, "Flood Protection for Nuclear Power Plants."
21. ANSI N170, "Standards for Determining Design Basis Flooding at Power Reactor Sites" (1976).
22. G. D. Ashton, et al., "Icebreaking by Tow on the Mississippi River," SR 192, CRREL, Hanover, New Hampshire, August 1973.
23. Roscoe E. Perham, "Forces Generated in Ice Boom Structures," SR 200, CRREL, Hanover, New Hampshire, January 1974.
24. George D. Ashton, "Air Bubbler Systems to Suppress Ice," SR 210, CRREL, Hanover, New Hampshire, September 1974.
25. Darryl J. Calkins and George D. Ashton, "Arching of Fragmented Ice Covers," SR 222, CRREL, Hanover, New Hampshire, April 1975.
26. W. H. Brierley, et al., "Lock Wall Deicing with Water Jets: Field Tests at Ship Locks in Montreal, Canada, and Sault Sainte Marie, Michigan," SR 239, CRREL, Hanover, New Hampshire, December 1975.
27. Bernard Michel, "Ice Pressure on Engineering Structures," CRREL, Hanover, New Hampshire, June 1970.
28. F. D. Haynes, et al., "Ice Force Measurements on the Pembina River, Alberta, Canada," SR 269, CRREL, Hanover, New Hampshire, October 1975.
29. K. L. Carey, et al., "Ice Engineering for Civil Works, Baseline Study," CRREL, Hanover, New Hampshire, August 1973.

30. 10 CFR Part 52. "Early Site Permits: Standard Design Certifications; and Combined Licenses for Nuclear Power Plants."
31. EM 1110-2-1406, "Runoff from Snowmelt," Corps of Engineers, March 31, 1998
32. EM 1110-2-1612 "Ice Engineering," Corps of Engineers, April 30, 1999